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(71) Applicant: BINTEL SYSTEMS, INC. [US/US]; 175 Lowell Street, Arlington, MA 02474 (US).

(72) Inventors: HILL, Gordon, W.; 175 Lowell Street, Arlington, MA 02474 (US). LLOYD, John, D.; 45 Andrew Avenue, Hull, MA 02045 (US). HILL, Lawrence, W.; 163 Waverly Street, Arlington, MA 02174 (US). BESEN, Matthew, M.; 9 Forbes Lane, Andover, MA 01810 (US).

(74) Agents: SCHURGIN, Stanley, M. et al.; Weingarten, Schurgin, Gagnebin & Hayes LLP, Ten Post Office Square, Boston, MA 02109 (US).

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(54) Title: INVENTORY CONTROL AND COMMUNICATION SYSTEM

(57) Abstract

An inventory control and communication system provides automated real–time polling of stock levels and ordering in a timely manner to allow optimal stock levels to be maintained. A storage unit, or bin, is established for each stock item. One or more transducers are associated with each storage unit to produce a signal indicative of the weight of the stock items stored in or at the corresponding storage unit. The signals are transmitted at regular intervals to a central inventory server, which maintains information about transducer location and the corresponding stock item, such as item weight and supplier information. Inventory logic in the central inventory server computes the quantity of each stock item from the transducer signals and the weight of the stock items. Iventory logic also includes threshold values for the minimum and maximum quantity of each stock item. When the quantity of a stock item reaches a minimum threshold, inventory logic sends an order to the supplier to restore the stock item to the maximum quantity threshold.

TITLE OF THE INVENTION

Inventory Control and Communication System

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. provisional patent applications No. 60/108,843, filed November 18, 1998, entitled Inventory Management System, and U.S provisional patent application No. 60/136,297, filed May 27, 1999, entitled Inventory Control and Communication System.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

BACKGROUND OF THE INVENTION

Inventory management systems are known which attempt to keep inventory of stock items at an optimal level based upon factors such as availability, possibility of price increase, lag time to reorder, and predictability of consumption rates. One such system is a Materials Requirements Planning (MRP) system, which is the primary manufacturing module of Enterprise Resource Planning (ERP) systems. Inventory ordering is performed through accurate forecasts of finished product demand and raw material availability, among other factors. Such systems, however, depend upon accurate market forecasting. Another inventory system is known as a

"Kanban" system, in which stock items are maintained with minimum and maximum thresholds. When the minimum threshold is reached, enough stock is ordered to bring the quantity back up to the maximum threshold. Timely examination of the stock item level is required, however, to ensure that the stock does not run out, and to ensure timely notification to a supplier to effect delivery.

It would be beneficial, therefore, to provide a system which performs automatic replenishment of stock through real-time polling of stock item quantity to avoid the need for periodic manual inspection of quantity and the need to maintain accurate market forecasts.

BRIEF SUMMARY OF THE INVENTION

An inventory control and communication system provides automated real-time polling of stock levels and ordering in a timely manner so that optimal stock levels are maintained. A storage unit, or bin, is established for each stock item. One or more transducers are associated with each storage unit to produce a signal indicative of the weight of the stock items stored in or at the corresponding storage unit. The signals are transmitted at regular intervals to a central inventory server, which maintains information about transducer location and the corresponding stock item, such as item weight and supplier information. Inventory logic in the central inventory server computes the quantity of each stock item from the transducer signals and the weight of the stock items. Inventory logic also includes threshold values for the minimum and maximum quantity of each stock

item. When the quantity of a stock item reaches the minimum threshold, inventory logic sends an order to the supplier to restore the stock item to the maximum quantity threshold, or otherwise indicates that a reorder is needed.

Inventory logic computes the quantity of the stock item from the transducer signals and the known weight of the predetermined stock item at the particular storage unit. The transducers, such as strain gauges, are disposed on or at each storage unit in such a manner so as to be sensitive to the weight of the stock items at the storage unit. Typically the strain gauges are mounted on the beams or supports bearing the weight of the storage unit, so as to detect shear, compression, and tension forces in the beams or supports. A transducer may be affected by multiple storage units. The inventory logic apportions the component of force imposed from a particular storage unit through precise positioning of the transducer relative to the storage unit. Also, multiple transducers may be used to measure the weight of a single storage unit. The inventory logic aggregates multiple readings so that a true quantity is computed regardless of the positioning of the stock items in or at the storage unit.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The invention will be more fully understood with reference to the following detailed description and drawings, of which:

Fig. 1 is a block diagram of the inventory control and communication system as defined by the present invention;

Fig. 2 is a context diagram of the system of Fig. 1;

Fig. 3 is an exploded view of an item bin storage unit as used in the present invention;

Fig. 4 shows the item storage bin of Fig. 3 with an expansion plate;

Fig. 5 shows the expansion plate of Fig. 4 attached to a sensor base;

Fig. 6a shows a rack storage unit as utilized in the present invention;

Fig. 6b shows the rack storage unit of Fig. 6a with shelves;

Fig. 7 shows a shelf storage unit having a plurality of sensor arrays;

Fig. 8a shows a side view of a pallet storage unit;

Fig. 8b shows a top view of the pallet storage unit of Fig. 8a;

Fig. 8c shows an alternate side view of the pallet storage unit of Fig. 8a;

Fig. 9a shows a horizontal fluid storage unit;

Fig. 9b shows a vertical fluid storage unit;

Fig. 9c shows a transmitter and gas cylinder storage unit;

Fig. 10a shows a plurality of wire spool storage units;

Fig. 10b shows sensor placement on one of the wire spool units of Fig. 10a;

Fig. 11a shows a perspective view of a circuit board transducer;

Fig. 11b shows a top view of the circuit board sensor of Fig. 11a;

Fig. 12 is a block diagram of the database and query GUI as used in the present invention;

Fig. 13 shows a block diagram of a storage transmission node;

Fig. 14 shows a flowchart of the storage transmission node logic; and

Fig. 15 shows the packet structure of the transducer signal packet sent from the storage transmission node.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Fig. 1, a block diagram of the inventory control and communication system 10 is shown as defined herein. One or more storage units, such as bins 12, store a quantity of a predetermined item. The quantity is proportional to the weight of the loaded bin 12. A transducer 14 senses the weight 16 of the bin 12, and produces a transducer signal 18 indicative thereof. The transducer signal 18 and the weight of the predetermined item is then used by quantity computation 20 to compute the quantity of the item in the respective bin 12. An item quantity signal 22 is sent to inventory control 24 which compares the quantity to minimum quantity thresholds for the particular item. If the quantity of a particular item is below the minimum threshold, inventory control 24 sends an order message 26 to a supplier to restock the item.

Referring to Figs. 1 and 2, the inventory control and communication system 10 as described above is shown in the context of a customer facility 30. A plurality of storage units 32 are located at a facility 30, such as a warehouse or manufacturing site. Each storage unit 32 is adapted to store a predetermined item 34 of a known weight. The storage units 32, described further below, may be bins, pallets, shelves, fluid tanks, wire spools, or other storage apparatus, and may be mounted in rows on a rack 34 or free standing, depending on the items so stored. One or more transducers 36 are associated with each storage unit, and located so as to sense the weight of the stored items 34. Each transducer 36 is connected to a storage transmission node 38, described further below, and sends to the storage transmission node 38 a transducer signal 18 indicative of weight. The storage transmission node 38 builds a transducer signal packet including one or more transducer signals according to a predetermined protocol.

The transducer signal packet is sent to a central inventory server 40, which receives transducer signal packets from other storage transmission nodes 38 at the facility 30. The central inventory server 40 is connected to an inventory database 42 which stores information about the item corresponding to each storage unit. For each storage unit 32, the weight of the item stored therein is maintained, as well as a minimum and maximum quantity threshold quantity for each item. The transducer signal packets are used to compute the quantity of the item remaining in the storage units, and

are compared to the minimum quantity threshold stored in the inventory database 42.

The inventory database 42 also contains supplier information for each item. The inventory server 40 will send an order to the supplier by any suitable means, such as via Internet 46, voice 48, cellular 44, or via paper mail 50 by printing an order on the attached printer 52. Alternatively, the inventory server 40 may send quantity information without requesting an order.

The inventory server 40 has a graphical user interface (GUI), described further below, for performing various inventory query functions. The GUI can be accessed locally through the server monitor 54, or accessed remotely from another computer 56.

TRANSDUCERS

Each of the transducers 36 as defined herein is operable to sense the weight, mass, or pressure of items 34 or substances contained in a storage unit 32. In a preferred embodiment the transducer is a strain gauge, and is attached to a load-bearing element supporting the storage unit 32, typically from beneath. A strain gauge provides a signal indicative of micromechanical deformations on the surface of a rigid member in response to forces applied thereto. A strain gauge disposed on a load bearing member supporting a storage unit delivers a signal indicative of the weight exerted by the items contained in or at the storage unit.

The range of sensitivity of the strain gauges is selected based on the weight of the predetermined item

and the quantity range expected. The strain gauges are affixed at a location which is subjected to forces exerted by the weight of the bin to which they correspond. The location at which the strain gauges are affixed takes various forms, described further below, depending upon the type of storage unit. The forces so exerted include tension, compression, and shear. Through appropriate calibration and signal amplification, the strain gauge signal indicative of the weight exerted by a particular storage unit can be used to accurately compute the total weight. The quantity of individual items can therefore be computed from the predetermined weight of individual items.

More than one strain gauge may be employed to sense the weight exerted by a particular storage unit. Multiple strain gauges are used to provide positional independence of the location of the item in or at the storage unit. Items located at a particular side of the storage unit may exert more force on that side. Multiple strain gauges can provide an offset such that the aggregate reading of all signals corresponding to a particular storage unit provides an accurate measurement of the total.

In alternative embodiments, other transducers may be employed to provide a signal indicative of the weight in or at a storage unit 32. Pressure sensitive resistors, resilient supports which selectively obscure a portion of a light beam, or electromechanical means such as a variable resistor may be employed.

STORAGE UNITS

The storage units 32 disclosed herein include several embodiments depending upon the types of items so stored. Referring to Fig. 3, a storage bin embodiment is shown. A storage bin 60 is adapted to be mounted on a support frame 62. The support frame 62 includes a center spine 64, cantilever moment arms 66, 68, and bearing arms 70, 72. The cantilever moment arms 66 and 68 are attached on top of the center spine 64 such that they extend equidistantly therefrom, and may be formed of a single piece. Bearing arms 70 and 72 are attached to the end of the cantilever moment arms 66, 68.

Two strain gauges are attached to the moment arms 66 and 68, preferable at a location where the mechanical deformations due to strain are the greatest, to maximize sensitivity. This location is the point just beyond that at which the moment arms 66, 68 extend from the center spine 64. One strain gauge 74 is mounted on the top of the moment arm 66, and measures increasing tension as the moment arm 66 is pushed downward from the weight of the bin 60 pushing against the bearing arm 70. The other strain gauge 76 is mounted on the bottom of the opposed moment arm 68, and measures compressive forces as the as the moment arm 68 is pushed downward from the weight of the bin 60. For maximum accuracy, the bin 60 and the strain gauges 74, 76 are symmetrically mounted over the support frame 62 and center spine 64. Since symmetrical positioning provides that the neutral axis is at the centerline of the support frame above the center spine 64, the aggregate strain gauge 74, 76 readings are

independent of the left-to-right location of the items in the bin. Further, strain gauges 74 and 76 are mounted parallel to the axis of the moment arms 66 and 68, providing for front-to-back positional independence of the items in the bin 60.

Resilient couplings 78 are used to attach the bearing arms 70, 72 to the bin 60. The resilient couplings 78 eliminate unwanted lateral forces which can affect the tension and compression sensed by the strain gauges 74 and 76 by restricting force exerted by the bin 60 to a vertical direction. The resilient couplings 78 also serve to cushion sudden surges of force which can interrupt accurate readings, such as from an object dropped or thrown into the bin 60.

In alternate embodiments, shown in Figs. 4 and 5, an anti-expansion plate 80 is attached between the resilient couplings 78 and the support frame 62. The plate 80 is constructed of the same material as the support frame 62. Strain gauge readings will therefore remain unaffected from thermal expansion resulting from different expansion coefficients between the bin 60 material and the support frame 62 material.

In another embodiment, shown in Figs. 6a and 6b, a rack storage unit adapted to store rigid, elongated items is shown. Referring to Fig. 6a, each storage unit 82 comprises a portion of a load bar 84 apportioned into individual storage units through separation stops 86. Strain gauges 88, adapted to measure shear force, are located at each of the separation stops 86 and also at the ends of the load bar 84. The weight exerted on the

load bar 84 by a particular storage unit 82 can be apportioned by measuring the component of force sensed from adjacent storage units based on the position of the strain gauges 88.

Referring to Fig. 6b, a shelf sensing system is shown similar to the embodiment disclosed in Fig. 6a. Each storage unit comprises a shelf 90 adapted to store free-standing items which do not require separation stops to ensure that they do not slide into an adjacent storage unit. Each shelf 90 is supported by a portion of the load bar 84. Strain gauges 88 measure force such that the weight exerted by a particular shelf 90 can be apportioned by measuring the component of force sensed from adjacent storage units 90.

Referring to Fig. 7, another embodiment is disclosed which shows the apportionment of forces from adjacent strain gauges. Two load bars 100, 102 are used to provide front-to-rear positional independence of items. Three independent forces F1-F3 are applied to storage units 104, 106, 108, respectively. Force F1 bearing on storage unit 104, for example is proportional to:

$$|(SG1A - SG2A)| + |(SG1B - SG2B)|$$

or, equivalently

$$|(SG1A + SG1B) - (SG2A + SG2B)|$$

Summarizing the general case, for a load between strain gauges SGn and SGn+1 on load bars A and B:

$$F(n) = |(SG(n)A + SG(n)B) - (SG(n+1)A + SG(n+1)B)|$$

The storage units 104, 106, 108 could be bins, elongated stock racks, shelves, or other configurations of items.

Referring to Figs. 8a-8c, a pallet embodiment is disclosed. Such pallets typically are used to store large, heavy items and adapted to be manipulated by mechanical means such as a forklift. A pair of base beams 110 each support cantilever beams 112. The cantilever beams 112 each support bearing posts 114, which bear the load of items stored on pallet planks and transmit forces downward onto the cantilever beams 112. Strain gauges 118 are affixed to the surface of the cantilever beams 112, at a point just before the beam 112 is attached to the base beams 110. Either tension or compression in the beams 112 may be measured, depending upon whether the strain gauges 118 are mounted on the top or bottom side, respectively, of the beams. The strain gauges are connected to a storage transmission node 38 located between the base beams.

In another embodiment fluid quantity is measured. Referring to Figs. 9a-9c, fluid tanks are shown. Fig. 9a shows a strain gauge 120 affixed to the bottom of a horizontal liquid tank 122, such as a home heating oil tank. A vertical tank 124 is shown in Fig. 9b. Strain gauge 120 is affixed near the bottom of the tank such that fluid level is proportional to forces detectable on the surface of the tank caused by the pressure of the fluid. The strain gauge 120 should be affixed away from structural aspects such as seams and legs which may affect the linearity of the response. Further, the

transducer signal is processed to accommodate the predetermined geometry of the tank, and may be processed using additional information such as the temperature of the fluid so stored. Fig. 9c shows attachment of a storage transmission node 38 to a gas cylinder 126.

Figs. 10a-10b show a wire spool embodiment. A horizontal rod 130 is adapted to store a spool 132 of wire. Fig. 10b shows the location of the strain gauge 134 and the sides 136 of the spool. The strain gauge 134 provides a signal which is indicative of the downward force of the corresponding spool 132. The quantity of wire remaining can be computed from the known weight of a segment of the wire so stored.

In another embodiment, a strain gauge is affixed to a printed circuit board (PCB) 140, as shown in Figs. 11a and 11b. Direct affixation to a printed circuit board facilitates electronic connections when the expected force is within a range which can be tolerated by a printed circuit board. Strain gauges 142 are glued or soldered to the surface on opposed sides, to sense both compression and tension. Alternatively, strain gauges 142 can be embedded within the board 140, as long as the strain gauges are located at the zero point 144 at the center of the board, so as to sense compression and tension equally. Further, PCB fabrication techniques may be used to fabricate strain gauge elements directly onto a structural member, such as a beam or support, supporting a storage unit.

TRANSDUCER POLLING

As indicated above in Fig. 2, each strain gauge 36 is connected to a storage transmission node 38 local to the storage units 32. Each storage transmission node 38 may be connected to strain gauges 36 corresponding to multiple storage units. Readings from each of the strain gauges 36 are transmitted to the central inventory server 40.

Referring to Fig. 13, a block diagram of the storage transmission node 38 is shown. Each strain gauge 36 is connected to a multiplexor 140. Multiplexor 140 polls each strain gauge 36 and sends the signals to the processor 142. The processor builds a transducer signal packet containing the transducer signals. A node address, identifying the storage transmission node, is read from a DIP switch 144. The node address distinguishes multiple storage transmission nodes which may be sending transducer signal packets to the central inventory server 40. The transducer signal packet 147 is shown in Fig. 15, and includes the node address 146, values for each strain gauge reading 148, and checksum fields 150. The transducer signal packet is sent to a radio transmitter 152 for transmission to the central inventory server 40 through an antenna 154. The storage unit node 38 is powered through a power supply/regulator 156, which may include a photovoltaic cell 157.

A flowchart of the storage transmission node logic is shown in Fig. 14. The processor is initialized at step 200 to begin polling at the first strain gauge. The signal from the next strain gauge is read, as depicted at

step 202. A value indicative of the signal is written to the proper position in the transducer signal packet, as shown at step 204. A sampling algorithm may be employed to provide verification through multiple successive reads. A check is made, as disclosed at step 206 to determine if all strain gauges have been polled. If not, iterate through each strain gauge in sequence, as depicted in step 208. When all strain gauges have been read, the storage transmission node address is read from DIP switch 144, as depicted in step 210. Checksum and header fields are written to the transducer signal packet, shown in step 212. A pause for the next pseudo-random transmission interval is performed, as disclosed in step 214 and described further below. When the transmission interval elapses, the transducer signal packet is sent to the central inventory server 40, as shown in step 216. The next pseudo-random transmission interval is selected, as shown at step 218, and control reverts to step 202.

SIGNAL PACKET TRANSMISSION

On a periodic basis, as indicated above with respect to Fig. 1, each storage transmission node 38 polls each transducer 36 connected to it in sequence to cause the transducer to send the transducer signal 18. Each storage transmission node 38, after polling each transducer 36, builds and sends the transducer signal packet to the central inventory server 40. In a preferred embodiment, transmission to the inventory server 40 is via a RF link 58 to an RF receiver 60, but

can be by any suitable means, such as Internet, power line, modem, LAN, WAN, IR, or other communication link.

Typically there will be a plurality of storage transmission nodes 38 at a facility. Each of these will be sending periodic transducer signal packets containing the latest transducer polling sequence. Transmission intervals to the inventory server 40 are therefore staggered pseudo-randomly, to avoid collisions between simultaneous transducer signal packets. Collisions which do occur, however, are unlikely to repeatedly affect the same storage transmission node, due to the pseudo-random staggering. Since the pseudo-random staggering makes it unlikely that a collision will repeatedly affect the same transmission node, subsequent transducer signal packets will ensure that the quantity counts remain current.

In a preferred embodiment, the storage transmission nodes comprise transmit only radios. Such radios do not require a two way protocol, therefore saving bandwidth. Accordingly, a pseudo-random interval avoids collisions without requiring a duplex protocol. Further, the interval determination uses the address of the storage transmission node, ensuring that two storage transmission nodes will not collide on consecutive cycles.

Referring again to Figs. 1 and 15, upon receipt by the central inventory server 40 the transducer signal packet is used to compute the quantity of items stored in each storage unit 32. For each storage unit, information concerning the corresponding storage transmission node 38, and the corresponding transducer signal values from the transducer signal packet (148 and 147 respectively,

Fig. 15) are used to compute the total weight contained in or at the storage unit. The quantity is determined from the individual item weight. The quantity is compared to minimum order threshold values, which indicate when an order is to be generated. When the quantity falls below the minimum threshold, an order is generated to replenish the quantity to a maximum quantity for the item. Also contained in the database 42 are supplier information and order methods, such as Internet, paper mail, or telephone, so that an automatic order may be generated and sent.

The database 42 is also connected to a GUI for various user interactions, shown in Fig. 12. The database is populated through a serial port 160 from the receiver 60 (Fig. 1). A main view screen 162 provides options allowing a user to access the various functions enumerated below. A single item detail view 164 screen allows graphical information concerning quantity of individual parts in relation to the minimum and maximum quantity thresholds. A replenish report view screen 166 provides information concerning frequency of orders placed for a particular item. A replenish request view screen 168 allows a manual item order to be placed via e-mail or fax. A storefront view screen 170 allows remote Internet access. An export database view screen 172 allows downloading to a remote client. An error report view screen 172 provides diagnostic feedback about system functions. Other queries and access to the database can be envisioned in addition to those enumerated here.

Those skilled in the art should readily appreciate that the programs defining the functions described herein can be delivered to a computer in many forms, including, but not limited to: (a) information permanently stored on non-writable storage media (e.g., read-only memory devices within a computer such as ROM or CD-ROM disks readable by a computer I/O attachment; (b) information alterably stored on writable storage medial (e.g., floppy disks, tapes read/write optical media and hard drives); or (c) information conveyed to a computer through a communication media, for example, using baseband signaling or broadband signaling techniques, such as over computer or telephone networks via a modem. The present embodiments may be implemented in a software executable out of a memory by a processor. Alternatively, the presently described functions may be embodied in part or in whole using hardware components such as Application Specific Integrated Circuits (ASICs), state machines, controllers or other hardware components or devices, or a combination of hardware components and software.

Those of ordinary skill in the art should further appreciate that variations to and modification of the above-described methods and apparatus for providing automated inventory computation and ordering may be made without departing from the inventive concepts disclosed herein. Accordingly, the invention should be viewed as limited solely by the scope and spirit of the appended claims.

CLAIMS

1. A system for determining inventory comprising:

a storage unit adapted to store a quantity of a predetermined item of known weight;

a transducer associated with the storage unit and operative to provide a transducer signal indicative of the weight of the items located in said storage unit; and

a central inventory server operable to receive said transducer signal from said transducer,

wherein said central inventory server is further operable to compute the quantity of said items in said storage unit using said transducer signal and said known weight.

2. The system of claim 1 wherein said transducer is one of a plurality of transducers.

3. The system of claim 2 wherein said storage unit is one of a plurality of storage units.

4. The system of claim 1 wherein said transducer signal is produced at regular, periodic intervals according to predetermined logic.

5. The system of claim 1 wherein said quantity is computed at regular, periodic intervals according to predetermined logic.

6. The system of claim 2 further comprising a storage transmission node operable to receive said transducer

signals and to build and send a transducer signal packet including said transducer signals to said central inventory server.

7. The system of claim 6 further comprising an RF link operable to transport said transducer signal packet to said central inventory server.

8. The system of claim 1 further including a supplier link connected to said central inventory server and operable to send an order to a supplier, wherein said order is sent when said quantity equals a predetermined threshold.

9. The system of claim 1 wherein said transducer signal is a voltage signal proportional to said weight of said items.

10. The system of claim 1 wherein said transducer is adapted to sense micromechanical deformations caused by said weight of said items.

11. The system of claim 1 wherein said transducer is selected from the group consisting of a strain gauge, a piezoelectric sensor, optical sensor, and a pressure sensitive resistor.

12. The system of claim 1 wherein said transducer is embedded in a printed circuit board.

13. The system of claim 3 wherein said inventory logic includes a list indicative of which of said predetermined stock corresponds to each of said storage units, and further indicative of which of said transducers corresponds to each of said storage units.

14. The system as in claim 1 wherein said transducer is mass sensitive.

15. The system as in claim 1 wherein said transducer is attached to an elongated horizontal beam underneath and bearing the weight of said storage unit.

16. The system as in claim 15 wherein said transducer is adapted to sense shear force on said elongated horizontal beam.

17. The system as in claim 16 wherein said transducer is attached to the side of said elongated horizontal beam.

18. The system as in claim 17 wherein said transducer is placed between said storage units.

19. The system as in claim 17 further comprising a plurality of horizontal beams underneath and bearing the weight of said storage unit.

20. The system as in claim 1 wherein said transducer is attached to horizontal cantilever members underneath and bearing the weight of said storage unit.

21. The system as in claim 20 wherein at least one transducer is attached to the compression side of said horizontal cantilever members and adapted to sense compression, and at least one sensor is attached to the tension side of said horizontal cantilever members and adapted to sense tension.

22. The system as in claim 1 wherein said storage unit is an open top bin.

23. The system as in claim 1 wherein said storage unit is a pallet.

24. The system as in claim 1 wherein said storage unit is a tank adapted to store fluid.

25. The system as in claim 1 wherein said storage unit is an elongated cylindrical shape adapted to store a spool in rotational communication therewith.

26. A transducer apparatus for determining the quantity of a predetermined item in a storage unit comprising:

a storage unit adapted to contain a plurality of predetermined items each having a common known weight;

a support element bearing the weight of said storage unit;

a transducer attached to said support element and operative to produce a transducer signal indicative of

said weight, wherein said quantity is deterministically related to said signal.

27. The transducer apparatus of claim 26 wherein said transducer is one of a plurality of transducers.

28. The transducer apparatus of claim 27 wherein said storage unit is one of a plurality of storage units.

29. The transducer apparatus of claim 26 wherin said transducer signal is a voltage signal proportional to said weight.

30. The transducer apparatus of claim 26 wherein said transducer is selected from the group consisting of a strain gauge, a piezoelectric sensor, and a pressure sensitive resistor.

31. The transducer apparatus of claim 26 wherein said transducer is disposed so as to be subjected to micromechanical deformations on at least a portion of said support element in response to said weight.

32. A method of inventory management for automatic replenishment of stock items through real-time inventory calculation comprising:

providing a storage unit adapted to store a quantity of a predetermined item of a known weight;

disposing a transducer operable to provide a transducer signal indicative of the weight of said storage units;

polling said transducer to receive said transducer signal;

computing, from said transducer signal and said known weight the quantity of predetermined stock items stored at said storage units.

33. The method as in claim 32 further comprising the steps of computing from said quantity signals a transducer signal packet including said transducer signal and the identity of a transmission unit node operable to send said transducer signal packet to a central inventory server; and

transmitting, to said central inventory server, said transducer signal packet.

34. The method of claim 33 wherein said step of transmitting is followed by comparing said quantity to a predetermined threshold.

35. The method of claim 34 further comprising sending an order to a supplier when said quantity equals said predetermined threshold.

36. The method of claim 32 wherein said transducer is one of a plurality of transducers.

37. The method of claim 36 wherein said storage unit is one of a plurality of storage units.

38. The method of claim 32 wherein said step of computing is performed at regular, periodic intervals according to predetermined logic.

39. The method of claim 33 wherein said step of transmitting to said central inventory server is via an RF link.

40. The method of claim 32 wherein said polling further comprises a plurality of pollings until multiple similar signals are received.

41. The method of claim 38 wherein said periodic polling intervals are pseudo-random intervals.

42. A computer program having computer readable program code for computing inventory quantity and generating automated orders comprising:

computer program code for signaling a transducer operable to provide a transducer signal indicative of the weight experienced by a storage unit;

computer program code for polling each of said transducers to receive said transducer signal;

computer program code for computing, from said transducer signal the quantity of predetermined stock itmes stored at said storage unit;

computer program code for computing from said quantity signals a transducer signal packet including said transducer signals and the identity of a transmission unit node operable to send said transducer signal packet to a central inventory server; and

computer program code for transmitting, to said central inventory server, said transducer signal packet.

43. The system of claim 1 wherein said central inventory server is further operable to compute said quantity using temperature.

44. The system as in claim 43 wherein said transducer is pressure sensitive.

45. The system of claim 1 wherein said quantity is computed at periodic intervals in response to an external event.

46. The system of claim 1 wherein said transducer associated with said storage unit is fabricated using PCB fabrication.

47. The system of claim 17 wherein said transducer is fabricated onto said horizontal beam using PCB fabrication.

48. The system of claim 1 further including a supplier link connected to said central inventory server and

operable to send said computed quantity to a supplier at regular intervals according to predetermined logic.

49. The system of claim 1 further including a supplier link connected to said central inventory server and operable to send said computed quantity to a supplier in response to an external event.

50. The method of claim 32 further comprising sending said quantity to a supplier at regular intervals according to predetermined logic.

51. The method of claim 32 further comprising sending said quantity to a supplier in response to an external event.

52. The method of claim 33 wherein said transmitting comprises transmitting in a transmit-only protocol.

53. A system for determining inventory comprising:

a storage unit adapted to store a quantity of a predetermined item;

a transducer associated with the storage unit and operative to provide a transducer signal indicative of the quantity of the items located in said storage unit; and

a central inventory server operable to receive said transducer signal from said transducer,

wherein said central inventory server is further operable to compute the quantity of said items in said storage unit using said transducer signal.

54. The system as in claim 53 wherein said transducer is pressure sensitive.

55. The system as in claim 6 wherein said transducer signal packet is sent to said central inventory server via a medium selected from the group consisting of Internet, LAN, WAN, power line modem, and IR.

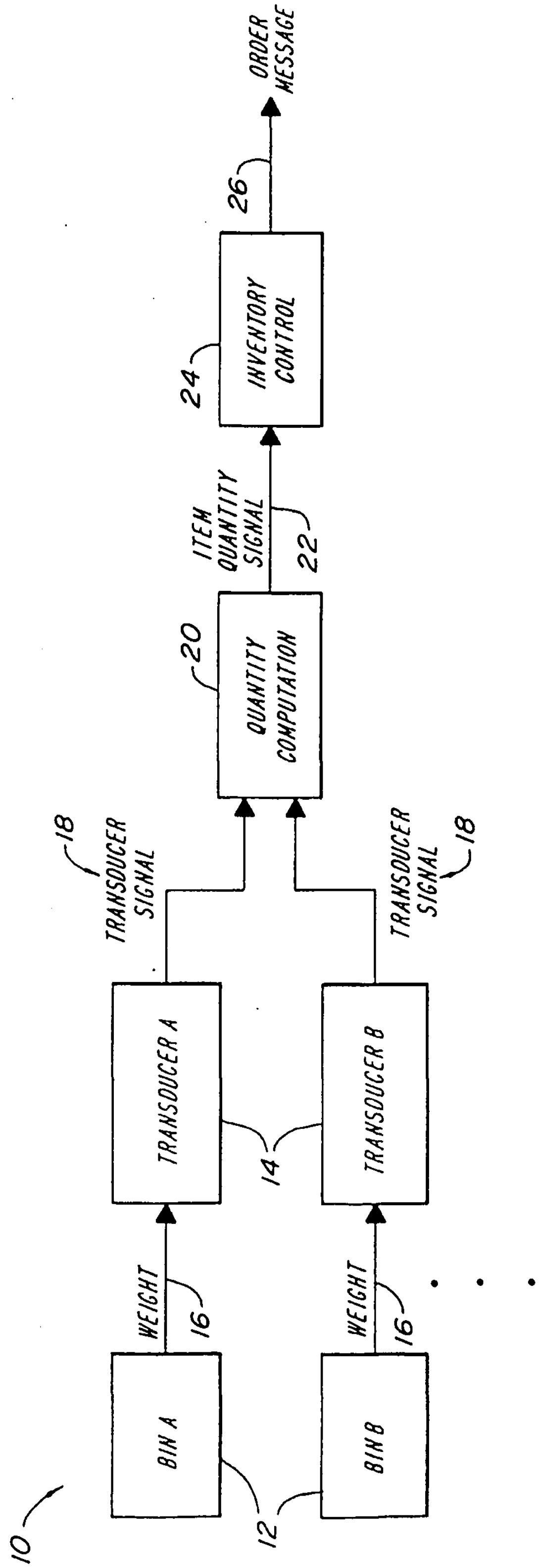

ORDER MESSAGE
26
INVENTORY CONTROL
24
ITEM QUANTITY SIGNAL
22
QUANTITY COMPUTATION
20
TRANSDUCER SIGNAL
18
TRANSDUCER SIGNAL
18
TRANSDUCER A
TRANSDUCER B
14
WEIGHT
16
WEIGHT
16
BIN A
BIN B
12
10

FIG. 1

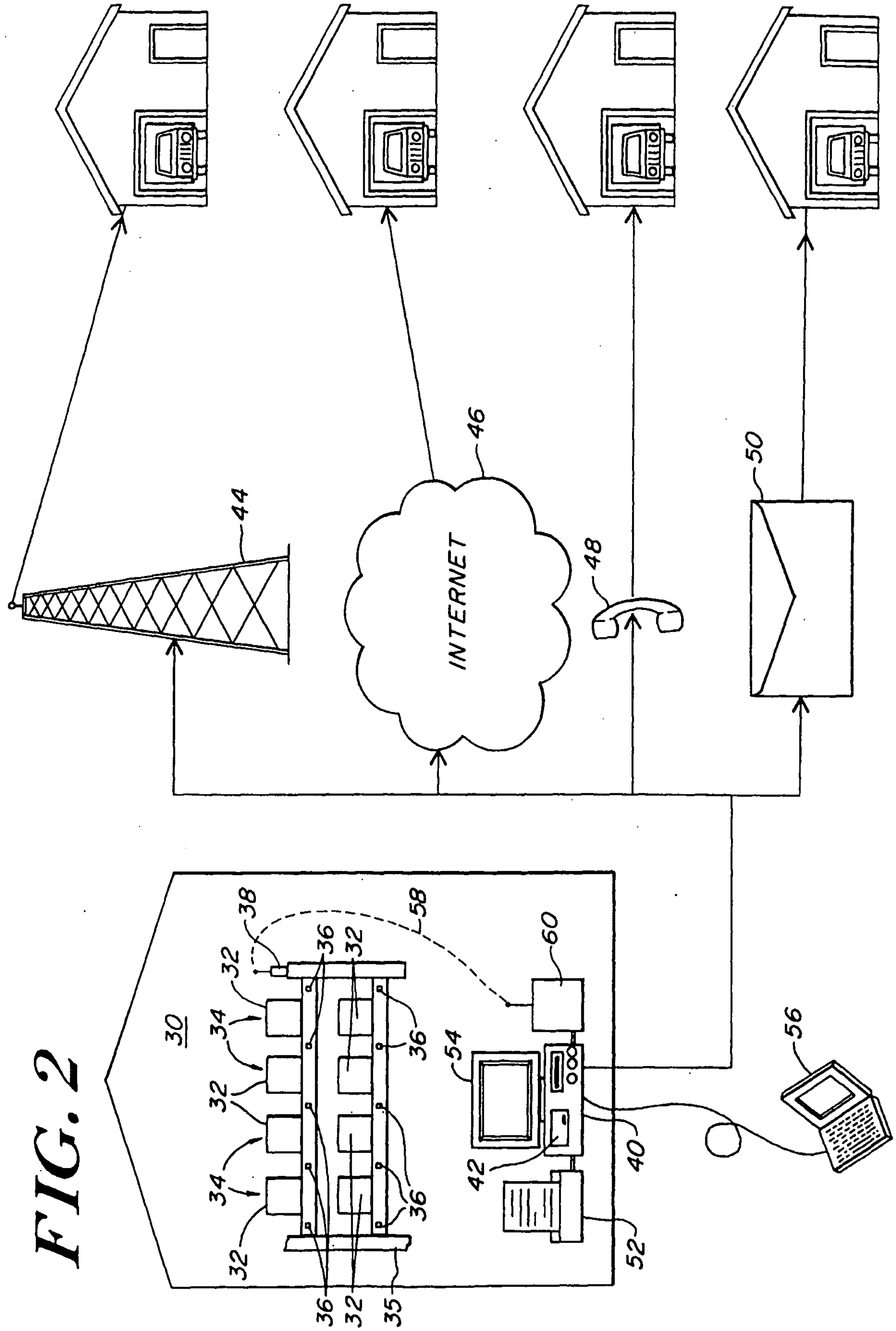


FIG. 2

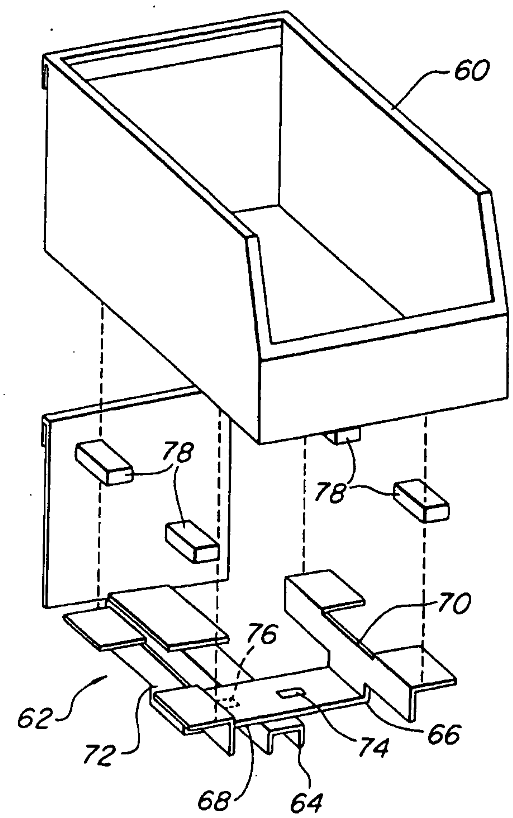


FIG. 3

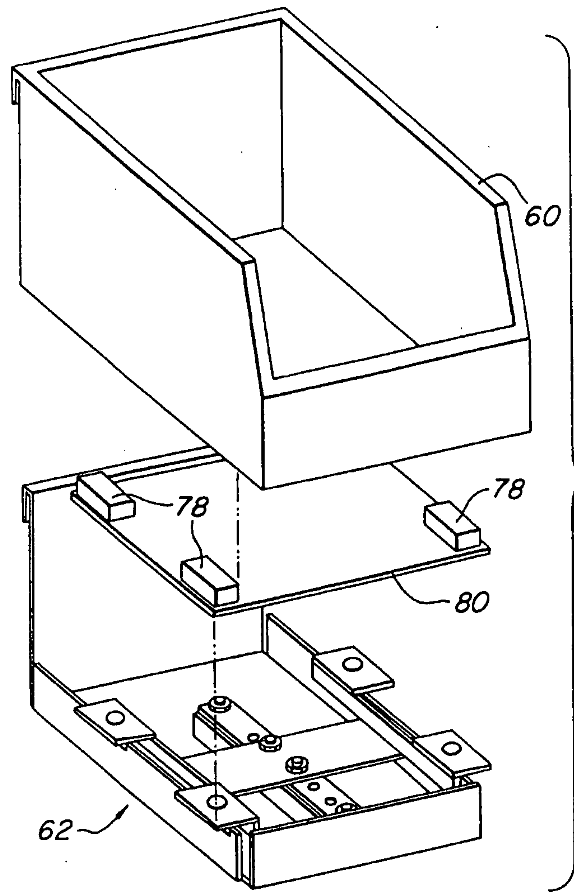


FIG. 4

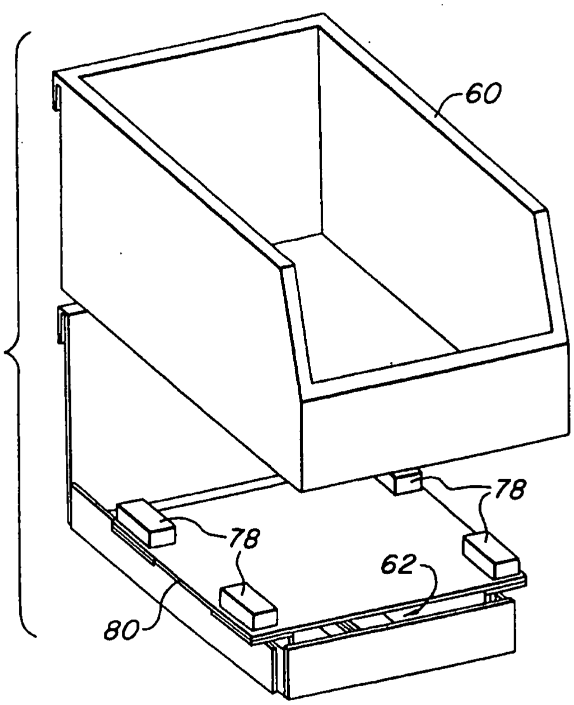


FIG. 5

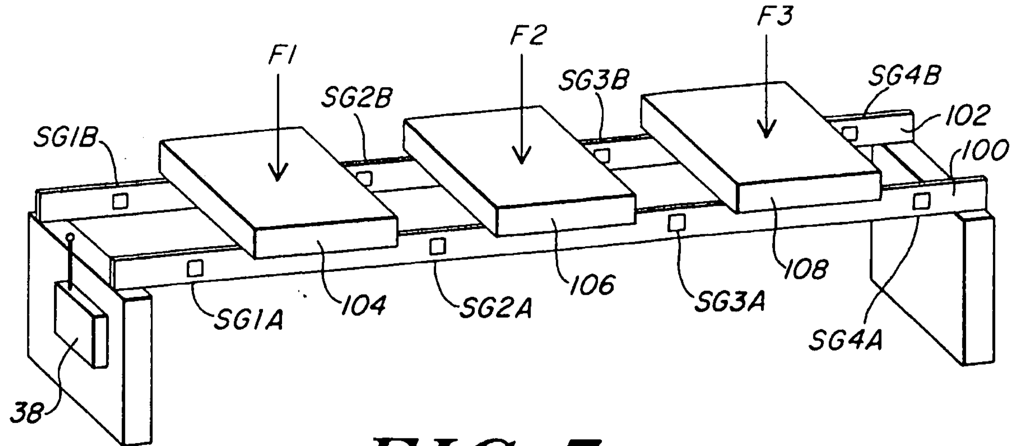


FIG. 7

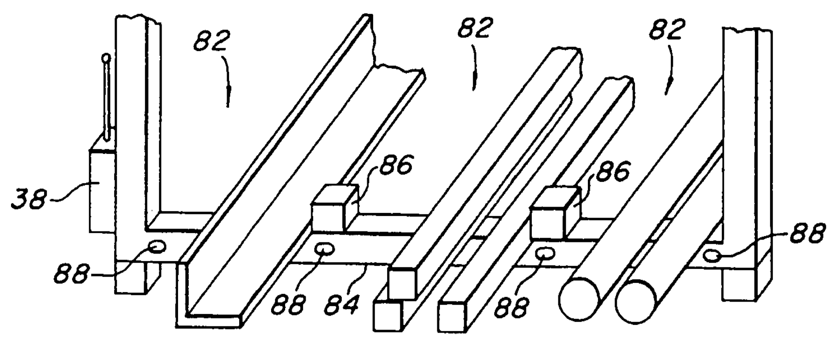


FIG. 6a

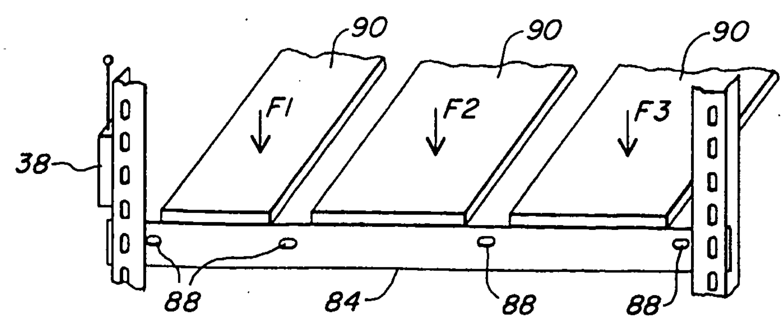


FIG. 6b

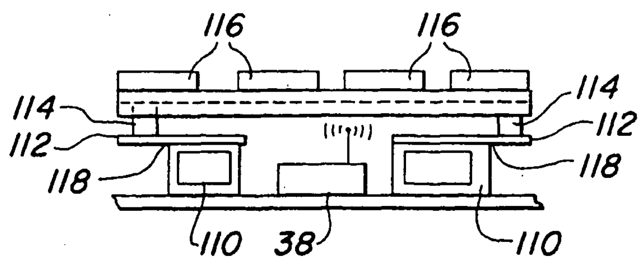


FIG. 8a

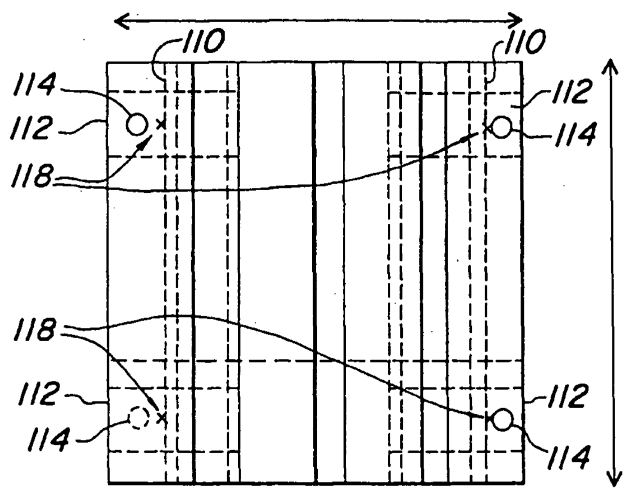


FIG. 8b

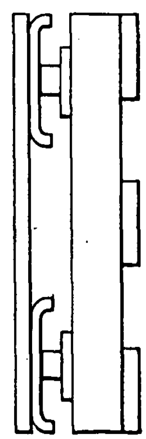


FIG. 8c

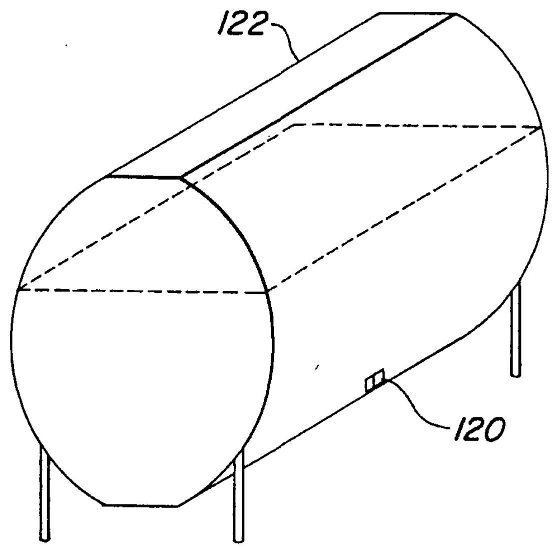


FIG. 9a

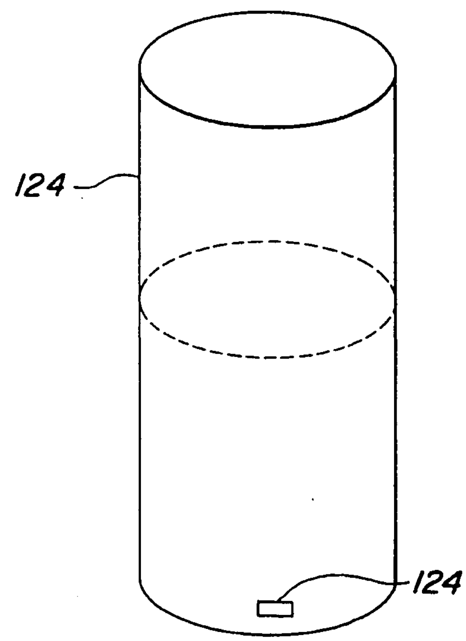


FIG. 9b

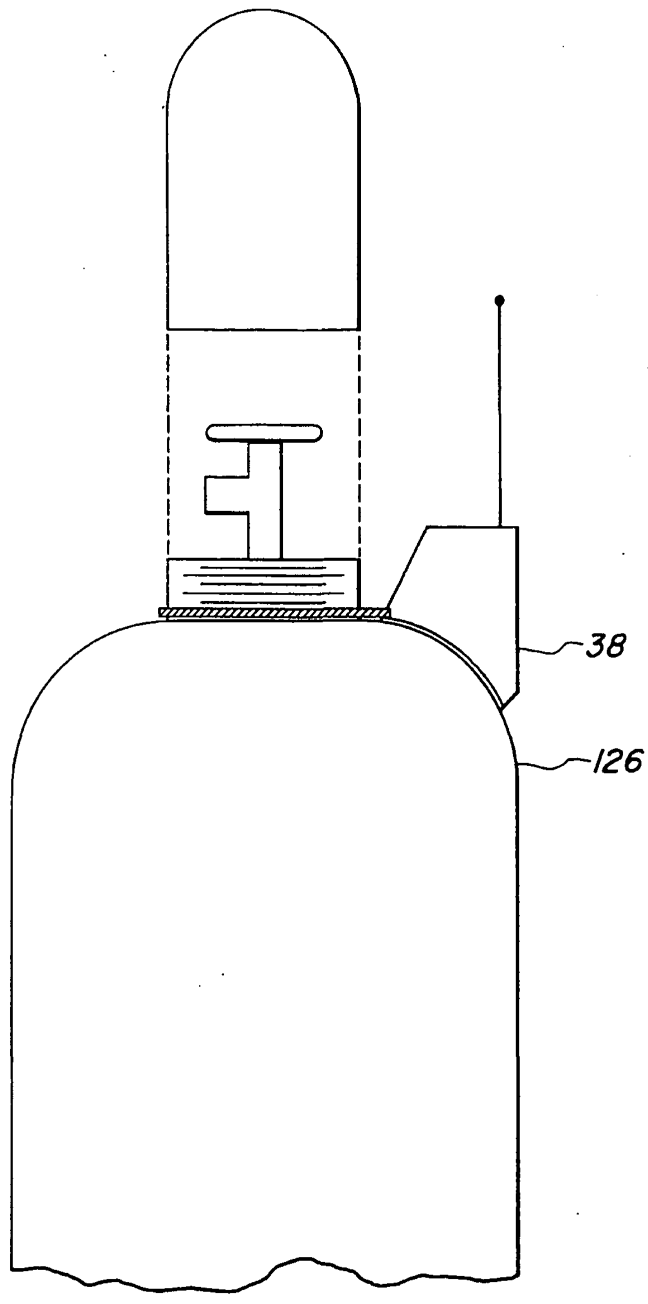


FIG. 9c

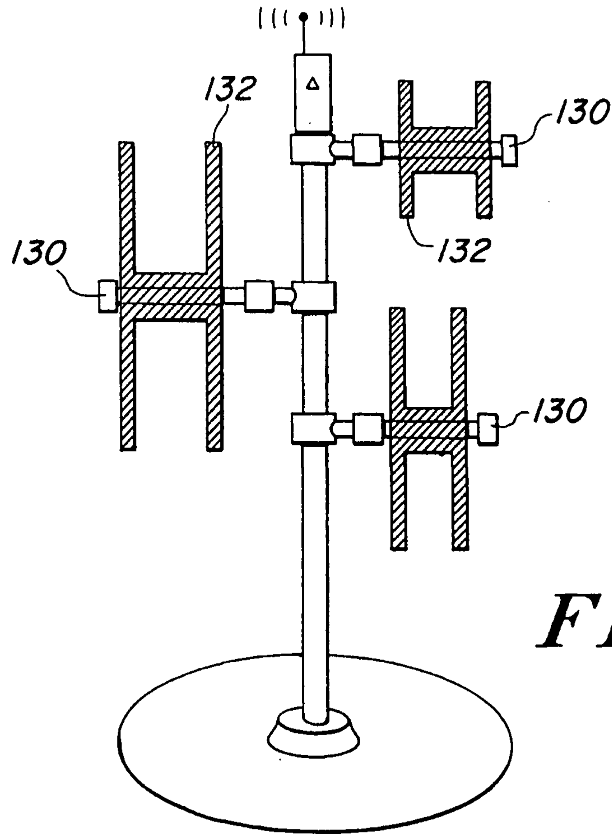


FIG. 10a

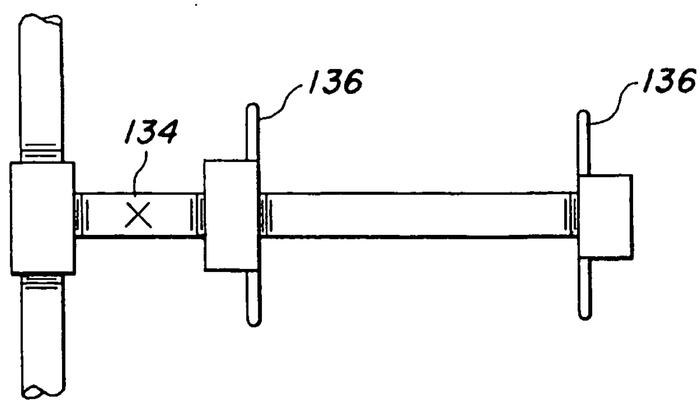


FIG. 10b

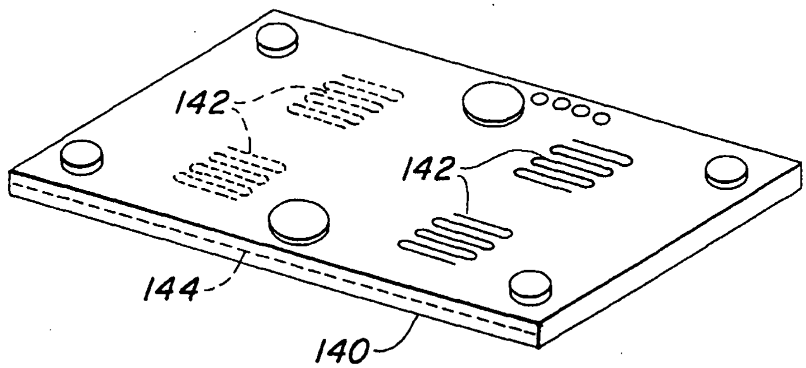


FIG. 11a

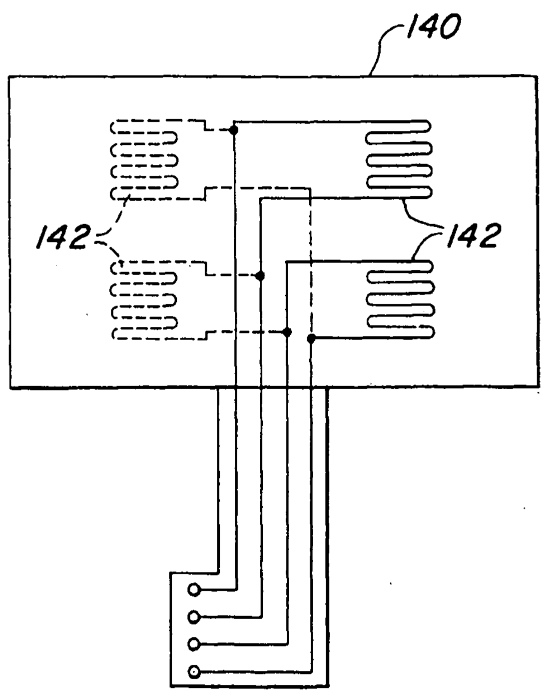
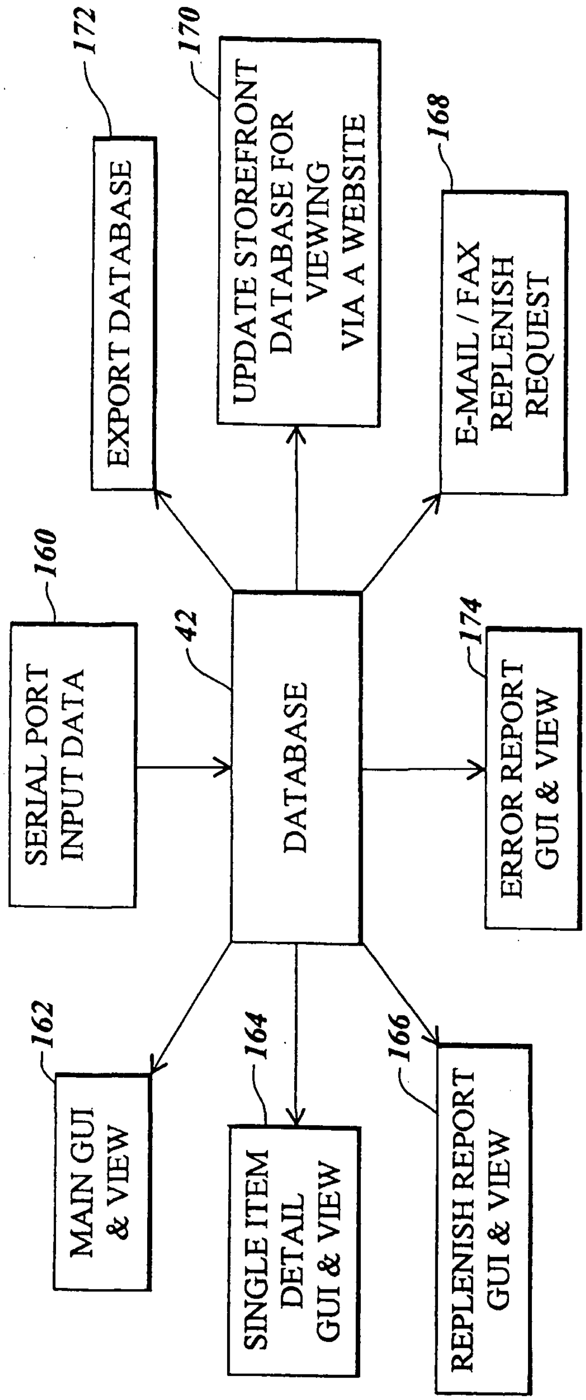


FIG. 11b



172
EXPORT DATABASE
170
UPDATE STOREFRONT DATABASE FOR VIEWING VIA A WEBSITE
168
E-MAIL / FAX REPLENISH REQUEST
160
SERIAL PORT INPUT DATA
42
DATABASE
174
ERROR REPORT GUI & VIEW
162
MAIN GUI & VIEW
164
SINGLE ITEM DETAIL GUI & VIEW
166
REPLENISH REPORT GUI & VIEW

FIG. 12

STORAGE TRANSMISSION NODE BLOCK DIAGRAM

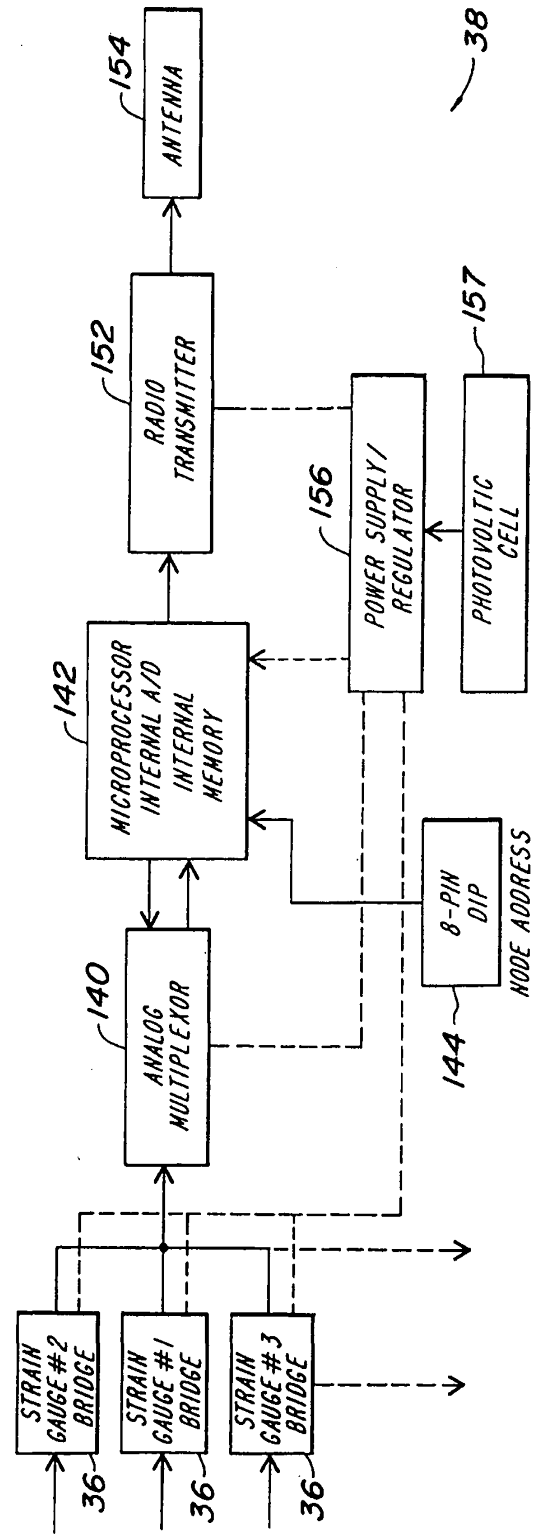
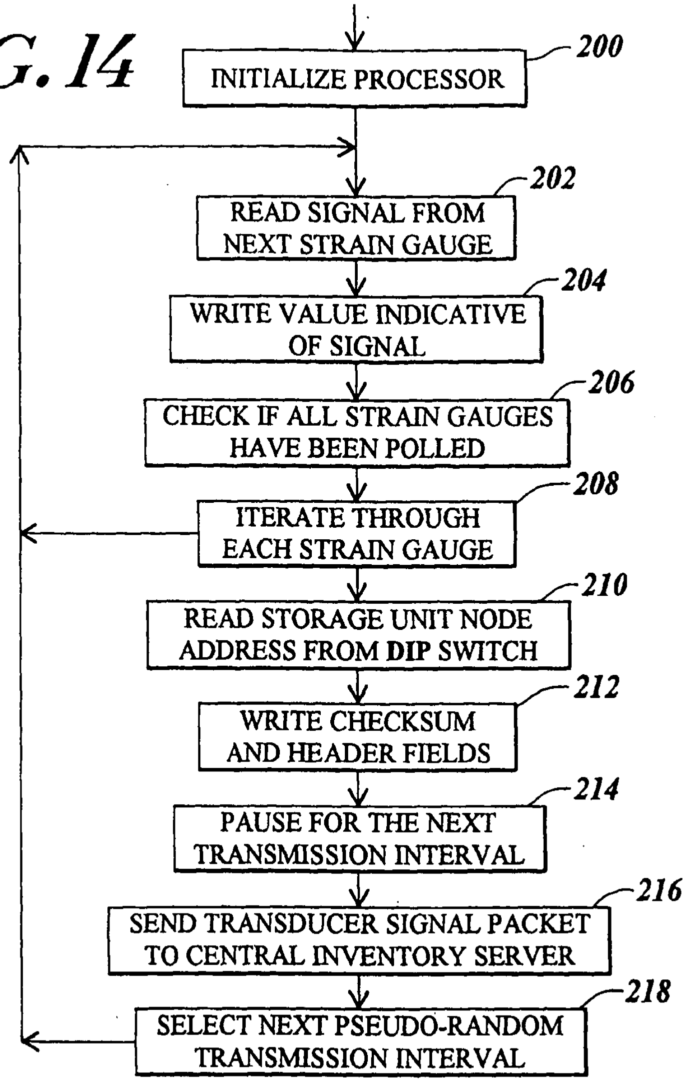


FIG. 13

FIG. 14


INITIALIZE PROCESSOR
200
READ SIGNAL FROM NEXT STRAIN GAUGE
202
WRITE VALUE INDICATIVE OF SIGNAL
204
CHECK IF ALL STRAIN GAUGES HAVE BEEN POLLED
206
ITERATE THROUGH EACH STRAIN GAUGE
208
READ STORAGE UNIT NODE ADDRESS FROM DIP SWITCH
210
WRITE CHECKSUM AND HEADER FIELDS
212
PAUSE FOR THE NEXT TRANSMISSION INTERVAL
214
SEND TRANSDUCER SIGNAL PACKET TO CENTRAL INVENTORY SERVER
216
SELECT NEXT PSEUDO-RANDOM TRANSMISSION INTERVAL
218

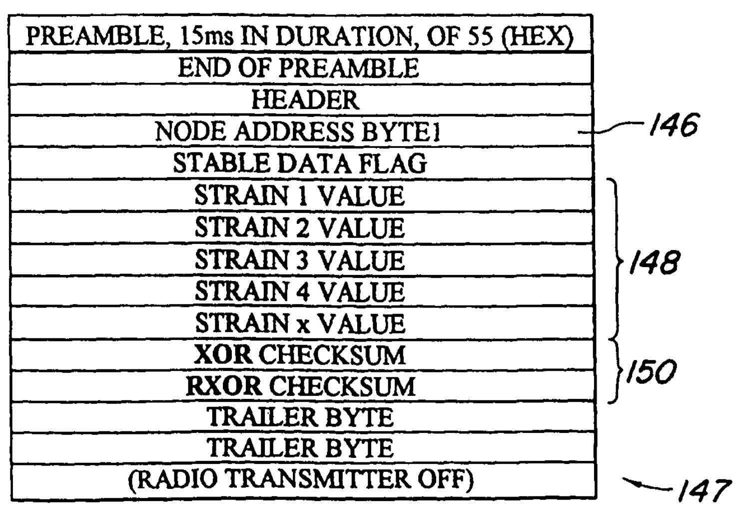

PREAMBLE, 15ms IN DURATION, OF 55 (HEX)
END OF PREAMBLE
HEADER
NODE ADDRESS BYTE1
146
STABLE DATA FLAG
STRAIN 1 VALUE
STRAIN 2 VALUE
STRAIN 3 VALUE
STRAIN 4 VALUE
STRAIN x VALUE
148
XOR CHECKSUM
RXOR CHECKSUM
150
TRAILER BYTE
TRAILER BYTE
(RADIO TRANSMITTER OFF)
147

FIG. 15